

FUEL CELL SYSTEM

Publication number: JP2002252011

Publication date: 2002-09-06

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Classification:

- **International:** H01M8/10; H01M8/04; H01M8/10; H01M8/04; (IPC1-7): H01M8/04; H01M8/10

- **European:**

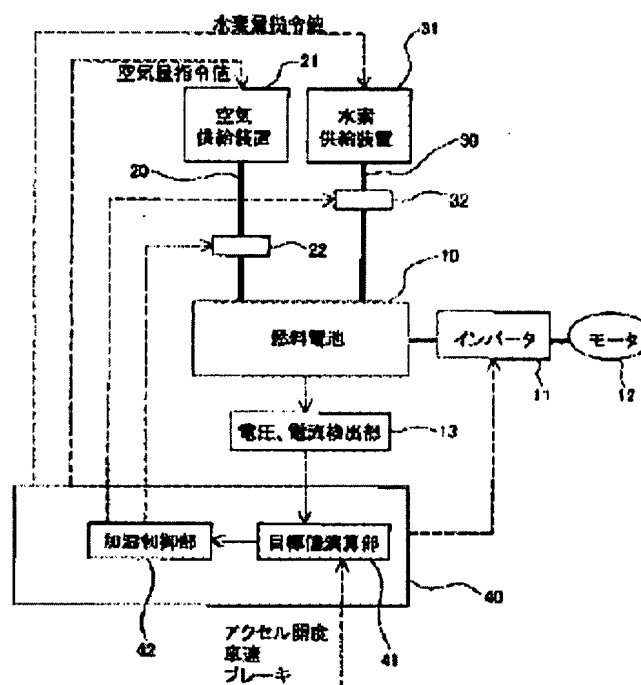
Application number: JP20010048712 20010223

Priority number(s): JP20010048712 20010223

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Abstract of JP2002252011

PROBLEM TO BE SOLVED: To provide a fuel cell system which enables efficient power generation while keeping a moisture state inside the fuel cell optimal. **SOLUTION:** A moistening degree of oxygen supplied to the fuel cell 10 is controlled based on a demanded electric power amount P_r to the fuel cell 10 and an internal resistance R_p of the fuel cell 10 calculated from an output voltage value and output current value which have been detected with a voltage current detection means 13. When a ratio of the internal resistance R_p to an internal resistance theoretical value R_r of the fuel cell 10 exceeds a predetermined value, since it can be presumed that moisture is insufficient, the moistening degree of the oxygen supplied to the fuel cell 10 is increased in the predetermined amount.



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JAPANESE [JP,2002-252011,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART TECHNICAL
PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

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CLAIMS

[Claim(s)]

[Claim 1] It is a fuel cell system equipped with the fuel cell (10) which carries out electrochemical reaction of hydrogen and the oxygen, and generates electrical energy. A humidification means to humidify oxygen at least among the hydrogen supplied to said fuel cell (10), and oxygen (22 24). An electrical-potential-difference current detection means to detect the output voltage value and output current value of said fuel cell (10) (13). It is based on the internal resistance value (R_p) of said fuel cell (10) calculated from the demand electric energy (P_r) over said fuel cell (10), said output voltage value detected with said electrical-potential-difference current detection means (13), and said output current value. The fuel cell system characterized by having the control section (40) which controls whenever [humidification / of the oxygen supplied to said fuel cell (10)].

[Claim 2] Said control section (40) is what performs the amount control of humidification so that whenever [humidification / of the oxygen supplied to said fuel cell (10)] may turn into whenever [target humidification]. The fuel cell system according to claim 1 characterized by carrying out the increment in a predetermined value of whenever [said target humidification] when the ratio of said internal resistance value (R_p) to the internal resistance theoretical value (R_r) of said fuel cell (10) in said demand electric energy (P_r) is over the predetermined value.

[Claim 3] Said control section (40) is a fuel cell system according to claim 2 characterized by carrying out the increment in a predetermined value of whenever [said target humidification] when the variation (ΔP_r) of said demand electric energy (P_r) is over predetermined variation.

[Claim 4] Said control section (40) is claim 1 characterized by setting up the initial value of whenever [said target humidification] highly as compared with the case where said current density is not over predetermined current density when the current density of said fuel cell (10) needed since said fuel cell (10) outputs said demand electric energy (P_r) is over predetermined current density thru/or the fuel cell system of any one publication of three.

[Claim 5] Said humidification means is bubbling-type humidification equipment (22) which makes the water stored in the tank pass gas. Said humidification equipment (22) is equipped with the bypass path (20a) for which the oxygen supplied to said fuel cell (10) can bypass said humidification equipment. Said control section (40)

Claim 1 characterized by for said oxygen controlling the rate of the time amount which passes said humidification equipment (22), and the time amount which passes said bypass path (20a), and controlling whenever [humidification / of said oxygen] thru/or the fuel cell system of any one publication of four.

[Claim 6] They are claim 1 which said humidification means is injector-type humidification equipment (24) which injects water into the oxygen supplied to said fuel cell (10), and is characterized by for said control section (40) controlling the moisture injection quantity of said humidification equipment (24), and controlling whenever [humidification / of said oxygen] thru/or the fuel cell system of any one publication of four.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention applies [to mobiles, such as a car, a vessel, and a portable electric organ,] about the fuel cell system which consists of a fuel cell which generates electrical energy by the chemical reaction of hydrogen and oxygen and is effective.

[0002]

[Description of the Prior Art] For example, in the fuel cell system carried in an electric vehicle, the amount of hydrogen and the amount of oxygen (air content) for generating the power which a fuel cell needs for car transit are drawn, and these gas is supplied to the fuel cell.

[0003] It is known that the internal resistance of the fuel cell at the time of a generation of electrical energy will influence the wettability of the electrolyte membrane inside a fuel cell, when sufficient humidity is not acquired but an electrolyte membrane dries, internal resistance becomes large and the power loss in a fuel cell increases. For this reason, in order to perform an efficient electric power supply, it is necessary to supply, where hydrogen and air are humidified and to maintain the humidity inside a fuel cell.

[0004]

[Problem(s) to be Solved by the Invention] However, in the present condition, control of the amount of humidification to the hydrogen and air which are supplied to a fuel cell is not performed. For this reason, lack or the case where it becomes superfluous has the moisture inside a fuel cell to the load which changes with time.

[0005] Drawing 12 shows the relation of the load to a fuel cell, a cel electrical potential difference, average current density, and the humidity of the air supplied, and when a load increases rapidly, if the moisture contents inside a fuel cell run short, the output of a fuel cell will decline. Thus, when moisture runs short, there is a problem that internal resistance increases and the output and generating efficiency of a fuel cell fall.

[0006] Moreover, there is a problem that the output of a fuel cell declines, without the water condensed in the interior of a fuel cell closing a gas passageway, and the gas for a generation of electrical energy spreading enough, or a generation of electrical energy is impossible by the water condensed at the time of low

temperature being frozen, and starting becomes difficult when moisture is superfluous.

[0007] In view of the above-mentioned trouble, this invention keeps the moisture condition inside a fuel cell the optimal, and aims at offering the fuel cell system which enables an efficient generation of electrical energy.

[0008]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, in invention according to claim 1 It is a fuel cell system equipped with the fuel cell (10) which carries out electrochemical reaction of hydrogen and the oxygen, and generates electrical energy. A humidification means to humidify oxygen at least among the hydrogen supplied to a fuel cell (10), and oxygen (22 24), An electrical-potential-difference current detection means to detect the output voltage value and output current value of a fuel cell (10) (13), It is based on the internal resistance value (R_p) of the fuel cell (10) calculated from the demand electric energy (P_r) over a fuel cell (10), and the output voltage value and output current value detected with the electrical-potential-difference current detection means (13). It is characterized by having the control section (40) which controls whenever [humidification / of the oxygen supplied to a fuel cell (10)].

[0009] Thus, the wettability of the electrolyte membrane inside a fuel cell (10) can be maintained at an optimum state by controlling whenever [humidification / of oxygen] based on the demand electric energy (P_r) over a fuel cell (10), and the internal resistance value (R_p) of a fuel cell (10). In addition, "oxygen" includes the air not only containing an oxygen gas independent but oxygen gas in this specification.

[0010] Moreover, by invention according to claim 2, since it can presume that the moisture in a fuel cell is insufficient when the internal resistance value of a fuel cell (10) is large, when the ratio of an internal resistance value (R_p) to the internal resistance theoretical value (R_r) of the fuel cell (10) in demand electric energy (P_r) is over the predetermined value, the increment in a predetermined value of whenever [target humidification] is carried out.

[0011] Moreover, by invention according to claim 3, since the moisture in a fuel cell runs short when the load effect of a fuel cell is large (i.e., when fluctuation of the demand electric energy over a fuel cell is large), when the variation (ΔP_r) of demand electric energy (P_r) is over predetermined variation, the increment in a predetermined value of whenever [target humidification / of oxygen] is carried out.

[0012] Moreover, in invention according to claim 4, the control section (40) is characterized by setting up the initial value of whenever [target humidification] highly as compared with the case where current density is not over predetermined current density, when the current density of the fuel cell (10) needed since a fuel cell (10) outputs demand electric energy (P_r) is over predetermined current density.

[0013] Thus, whenever [air target humidification] can be made into a quicker suitable value by setting up the initial value of whenever [air target humidification] low at the time of low loading, and setting it up highly at the time of a heavy load. In addition, it may replace with the current density of a fuel cell

(10), and the initial value of whenever [target humidification] may be set up based on the demand electric energy over a fuel cell.

[0014] Moreover, a humidification means can use the bubbling-type humidification equipment (22) which passes gas for the water stored in the tank like invention according to claim 5, or can use the injector-type humidification equipment (24) which injects water for the oxygen supplied to a fuel cell (10) like invention according to claim 6.

[0015] In addition, the sign in the parenthesis of each above-mentioned means shows correspondence relation with the concrete means of a publication to the operation gestalt mentioned later.

[0016]

[Embodiment of the Invention] (The 1st operation gestalt) The 1st operation gestalt of this invention is hereafter explained based on drawing 1 - drawing 8 . A **** 1 operation gestalt applies a fuel cell system to the electric vehicle (fuel cell car) which runs a fuel cell as a power source.

[0017] Drawing 1 shows the whole fuel cell system configuration of an operation gestalt. As shown in drawing 1 , the fuel cell system of this operation gestalt is equipped with the fuel cell (FC stack) 10 which generates power using the electrochemical reaction of hydrogen and oxygen. The solid-state polyelectrolyte mold fuel cell is used as a FC stack 10, two or more laminatings of the cel used as a base unit are carried out, and it consists of **** 1 operation gestalten. Each cel has the composition that the electrolyte membrane was inserted with the electrode of a pair.

[0018] In the FC stack 10, the electrochemical reaction of the following hydrogen and oxygen occurs and electrical energy occurs.

(Negative-electrode side) The $H_2 \rightarrow 2H^{++} + 2e^-$ (positive-electrode side)

$2H^{++} + 1/2O_2 + 2e^- \rightarrow H_2O$ FC stack 10 is constituted so that power may be supplied to electrical machinery and apparatus, such as an inverter 11 and a rechargeable battery which is not illustrated. An inverter 11 changes into alternating current the direct current supplied from the FC stack 10, supplies it to a drive motor (load) 12, and is driving the motor 12. Drawing 2 is the enlarged drawing of the electrical-potential-difference current detecting element of the FC stack 10 in a fuel cell system, and as shown in drawing 2 , the electrical-potential-difference current detecting element 13 which detects the output voltage value and output current value of the FC stack 10 is formed in the FC stack 10.

[0019] Drawing 3 is the enlarged drawing of the gas supply section in a fuel cell system. As shown in drawing 3 , the air path 20 for supplying air (oxygen) to the oxygen pole (positive electrode) side of the FC stack 10 and the hydrogen path 30 for supplying hydrogen to the hydrogen pole (negative electrode) side of the FC stack 10 are formed in the fuel cell system. Air supply equipment 21 is formed in the air path 20, and the hydrogen feeder 31 is formed in the hydrogen path 30. As air supply equipment 21, the blower for air feeding (gas-compression machine) can be used, for example, and steam-reforming equipment can be used as a hydrogen feeder 31, for example.

[0020] It is necessary to make the electrolyte membrane in the FC stack 10 into the damp or wet condition containing moisture for the electrochemical reaction at

the time of a generation of electrical energy. For this reason, the humidification equipment 22 for humidifying to air is formed in the air path 20. Similarly, the humidification equipment 32 for humidifying in hydrogen is formed in the hydrogen path 30. As shown in drawing 3, with the **** 1 operation gestalt, the humidification equipment of the bubbling method which the water in a tank is made to pass gas and is humidified in it is used for the humidification equipments 22 and 32.

[0021] Humidification is performed in the hydrogen which passes the air and the hydrogen path 30 of passing the air path 20, with these humidification equipments 22 and 32, and the air and hydrogen which were humidified are supplied to the FC stack 10. By this, the FC stack 10 interior will operate by the damp or wet condition.

[0022] In the fuel cell system of a **** 1 operation gestalt, as shown in drawing 3, the bypass paths 20a and 30a of the humidification equipments 22 and 32 are formed in the air path 20 and the hydrogen path 30, respectively. The passage selector valves 23 and 33 are formed in the branch point of each gas paths 20 and 30 and bypass paths 20a and 30a. the passage selector valves 23 and 33 -- it is constituted so that gas may be passed to humidification equipment 21 and 31 side and gas may be passed to the bypass path 20a and 30a side in a sink and bulb-off by bulb-on.

[0023] Here, the amount control of humidification to the air or hydrogen by the humidification equipments 22 and 32 is explained. The amount control of humidification of the gas supplied to the FC stack 10 carries out duty ratio control of the passage selector valves 23 and 33, and is performed because gas controls the time amount rate of passing through the humidification equipments 22 and 32 and the bypass paths 20a and 30a.

[0024] Drawing 4 is the control explanatory view of the humidification equipments 22 and 32. Drawing 4 (a) is the map which set up beforehand the relation between Hr (%RH: relative humidity) and the bulb-on duty Dt (%) whenever [target humidification], and drawing 4 (b) shows the relation between the valve-action period Tp (second) and the bulb-on time amount Ton (second). The bulb-on duty Dt is the rate of the bulb-on time amount Ton in the valve-action period Tp. The map of drawing 4 (a) is suitably set up according to the class of humidification equipments 22 and 32 etc. The valve-action period Tp can be set as arbitration, and is made into Tp= 5 seconds with this operation gestalt.

[0025] Based on whenever [target humidification], the bulb-on duty Dt is searched for from the map of drawing 4 (a), and the bulb-on time amount Ton over the valve-action period Tp is found by $Ton = T_p \times Dt / 100$ (second).

[0026] Drawing 5 shows the migration condition of the moisture in the FC stack 10 interior. As shown in drawing 5, in the FC stack 10 interior, the moisture by the side of air pole 10c diffuses the inside of electrolyte membrane 10b in the hydrogen pole 10a side from the air pole 10c side. The conductivity of electrolyte membrane 10b will be kept to some extent large by this moisture diffusion.

[0027] Drawing 6 shows the relation of hydrogen humidity (%RH) in case air humidity is 100%RH, current density (A/cm²), and single cell voltage (V). Drawing 6 shows that the relation between current density and a cel electrical potential

difference hardly receives effect in change of hydrogen humidity.

[0028] Therefore, by the fuel cell system of a **** 1 operation gestalt, the amount of humidification of hydrogen is reduced as much as possible, and humidity control of the FC stack 10 interior is performed by mainly controlling the amount of humidification of air.

[0029] The control section (ECU) 40 which performs various control is formed in the fuel cell system of this operation gestalt. The control section 40 is equipped with the desired value operation part 41 which calculates whenever [target humidification / of gas], and the amount control section 42 of humidification which controls the amount of gas humidification based on whenever [target humidification]. An electrical-potential-difference value, a current value, etc. from a demand power signal and the electrical-potential-difference current detecting element 13 from a load 11 are inputted into a control section 40. Moreover, the control section 50 is constituted so that a control signal may be outputted to an inverter 11, gas transfer units 21 and 31, the passage selector valve 23, and 33 grades.

[0030] Next, actuation of the fuel cell system of the above-mentioned configuration is explained based on drawing 7 . Drawing 7 is a flow chart which shows actuation of the fuel cell system of this operation gestalt. In addition, let control periods be several mm second – dozens mses.

[0031] First, the target humidity Hh of hydrogen is set up (step S10), and the target humidity basic value Hbo of air is set up (step S11). The hydrogen target humidity Hh is set for example, as RH 20%, and the air target humidity basic value Hbo is set for example, as RH 30%. The initial value of the air target humidity correction value Hfbo is set as 0 (step S12).

[0032] Next, based on signals, such as accelerator opening, the vehicle speed, and a brake, the demand power Pr needed for car transit is detected (step S13). Difference ΔPr with the demand power Pr at the time of control (t-1) is computed the current demand power Pr (t) and last time (step S14), and it judges whether variation ΔPr of demand power is over the predetermined value alpha (for example, 5kW) (step S15). That is, it judges whether the load effect to the FC stack 10 is rapid increase.

[0033] Consequently, when variation ΔPr of demand power is over the predetermined value alpha, first, the electrical-potential-difference current detecting element 13 detects the current output voltage value **** and the current output current value Ip of the FC stack 10 (step S16), and the current internal resistance value Rp of the FC stack 10 is computed by $Rp = **** / Ip$ (step S17).

[0034] Next, the internal resistance reference value Rr of the FC stack 10 in the demand power Pr detected at the above-mentioned step S13 is calculated (step S18). Drawing 8 is the map which set up beforehand the relation between the demand power Pr and the internal resistance value Rr of the FC stack 10. From the map shown in drawing 8 , the internal resistance reference value Rr when the FC stack 10 outputs the demand power Pr is calculated.

[0035] Next, it judges whether the ratio to the internal resistance reference value Rr in the demand power Pr of the current internal resistance value Rp is over the

predetermined value β (for example, 110%), and whether it is $R_p/R_r \geq \beta$ (step S19). That is, it judges whether the actual internal resistance value R_p is too large to the internal resistance reference value R_r which is an internal resistance theoretical value to the demand electric energy P_r .

[0036] Consequently, since it is presumed that the actual internal resistance value R_p runs short of the moisture contents in the FC stack 10 beyond the predetermined value to the internal resistance reference value R_r in being large, only the predetermined value γ (for example, 1%RH) makes the air target humidity correction value H_{fbo} increase (step S20).

[0037] On the other hand, since it is presumed to the internal resistance reference value R_r that the moisture contents in the FC stack 10 are insufficient when the current internal resistance value R_p is smaller than a predetermined value, only the predetermined value γ decreases the air target humidity correction value H_{fbo} (step S21). Moreover, also when variation ΔP_r of demand power is not over the predetermined value α at the above-mentioned step S15, only the predetermined value γ decreases the air target humidity correction value H_{fbo} similarly. It can prevent that the amount of air humidification to which it is made to increase at step S20 increases to infinity by this.

[0038] Next, it asks for the final air target humidity H_o from the sum of the air target humidity basic value H_{bo} and the air target humidity correction value H_{fbo} (step S22). A bound value is set as this air target humidity H_o (step S23). That is, when the air target humidity H_o is smaller than 0%RH, it is set as RH 0%, and in being larger than 100%RH, it sets it as RH 100%.

[0039] Next, based on the air target humidity H_o and the hydrogen target humidity H_h , the humidification equipments 22 and 32 perform humidification control of air or hydrogen (step S24). As mentioned above, humidification control is performed by the duty ratio control using the passage selector valves 23 and 33 so that whenever [humidification / of the air and hydrogen which are supplied to the FC stack 10] may turn into the air target humidity H_o and the hydrogen target humidity H_h . Hereafter, it carries out by repeating the control loop of the above-mentioned steps S13–S24.

[0040] As mentioned above, an internal resistance value is presumed according to the condition of a load, and it becomes possible by controlling the amount of humidification of gas based on this internal resistance value to always make the optimal the moisture condition of the FC stack 10 interior. Thereby, an efficient generation of electrical energy is attained. Moreover, since the moisture content inside a fuel cell can be lessened, the starting nature of the fuel cell at the time of low temperature can also be raised.

[0041] In addition, the hydrogen target humidity H_h , the air target humidity basic value H_{bo} , and the predetermined values α , β , and γ are values which can be set as arbitration according to the class of fuel cell etc.

[0042] (The 2nd operation gestalt) Next, the 2nd operation gestalt of this invention is explained based on drawing 9. It differs in that the humidification equipment 32 with which the **** 2 operation gestalt was prepared in the hydrogen path 30 as compared with the above-mentioned 1st operation gestalt was omitted. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and

omits explanation.

[0043] Drawing 9 shows the whole fuel cell system configuration of a **** 2 operation gestalt. As the above-mentioned 1st operation gestalt explained based on drawing 5 and drawing 6, the output of a fuel cell hardly receives effect in the humidity of supply hydrogen. For this reason, as shown in drawing 9, in the fuel cell system of a **** 2 operation gestalt, humidification equipment is not formed in the hydrogen path 30, but humidification equipment 22 is formed only in the air path 20, and humidity control of the FC stack 10 interior is performed by controlling the amount of humidification of a supply air.

[0044] In the FC stack 10 interior, since the moisture by the side of an air pole diffuses the inside of an electrolyte membrane in a hydrogen pole side, the conductivity of an electrolyte membrane is kept to some extent large by such configuration. Therefore, the same effectiveness as the fuel cell system of the above-mentioned 1st operation gestalt can be acquired also by the configuration of a **** 2 operation gestalt. Moreover, according to the configuration of a **** 2 operation gestalt, simplification of a system can be attained.

[0045] (The 3rd operation gestalt) Next, the 3rd operation gestalt of this invention is explained based on drawing 10. As compared with the above-mentioned 1st operation gestalt, as for a **** 3 operation gestalt, the setting approaches of the air target humidity basic value H_{bo} differ. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.

[0046] Drawing 10 is a flow chart which shows the configuration procedure of the air target humidity basic value H_{bo} , and supports step S11 of drawing 7 explained with the above-mentioned 1st operation gestalt. Hereafter, based on drawing 10, the setting approach of the air target humidity basic value H_{bo} in a **** 3 operation gestalt is explained.

[0047] First, based on signals, such as accelerator opening, accelerator opening, the vehicle speed, and a brake, the demand electric energy P_r needed for car transit is detected (step S110). Next, the current density I_r required since the FC stack 10 outputs the demand electric energy P_r is computed (step S111). The need [of receiving the demand electric energy P_r] current density I_r becomes settled uniquely according to the class of inverter 11.

[0048] Next, it judges whether the load to whether the need current density I_r is over predetermined current density and the FC stack 10 is a heavy load, or it is low loading (step S112). The predetermined current density which is the reference value of whether it is a heavy load or to be low loading is the value which can be set as arbitration according to the class of fuel cell etc., for example, as shown in drawing 12, it can be set up with 0.3 A/cm².

[0049] Consequently, when the need current density I_r is over the predetermined value, the air target humidity basic value H_{bo} is set for example, as RH 80 to 100% (step S113). On the other hand, when the need current density I_r is not over the predetermined value, the air target humidity basic value H_{bo} is set for example, as RH 20 to 30% (step S114). It is the value which can also set these values as arbitration according to the class of fuel cell etc.

[0050] Thus, H_o can be made into a quicker suitable value whenever [air target humidification] by setting up the initial value of the air target humidity H_o low at

the time of low loading, and setting it up highly at the time of a heavy load.

[0051] (The 4th operation gestalt) Next, the 4th operation gestalt of this invention is explained based on drawing 11 . As for a **** 4 operation gestalt, the configurations of the humidification equipments 22 and 32 differ as compared with the above-mentioned 1st operation gestalt. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.

[0052] Drawing 11 is the schematic diagram of the fuel cell system of a **** 4 operation gestalt. The same part as the above-mentioned 1st operation gestalt is omitting illustration suitably.

[0053] As shown in drawing 11 , with the **** 4 operation gestalt, the injector-type gas humidification equipments 24 and 34 are formed. Pure water is supplied from the pure tank 14, and the injector type humidification equipments 24 and 34 inject water in a gas passageway 20 and 30 based on the control signal from a control section 40, and they are constituted so that it may humidify in gas. Based on the air target humidity H_o and the hydrogen target humidity H_h , the moisture injection quantity is controlled by the injector type humidification equipments 24 and 34.

[0054] Responsibility becomes possible [performing highly precise humidification control] well more by using such injector type humidification equipments 24 and 34.

[0055] (Other operation gestalten) although controlled in addition by establishing the bypass paths 20a and 30a in the bubbling type humidification equipments 22 and 32, and carrying out duty ratio control whenever [humidification] with the above 1st - the 3rd operation gestalt -- not only this -- for example, humidity control can be performed also by adjusting the temperature of the humidified gas. By raising gas temperature, humidity can be made low and, specifically, humidity can be made high by lowering gas temperature.

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TECHNICAL FIELD

[Field of the Invention] This invention applies [to mobiles, such as a car, a vessel, and a portable electric organ,] about the fuel cell system which consists of a fuel cell which generates electrical energy by the chemical reaction of hydrogen and oxygen and is effective.

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PRIOR ART

[Description of the Prior Art] For example, in the fuel cell system carried in an electric vehicle, the amount of hydrogen and the amount of oxygen (air content) for generating the power which a fuel cell needs for car transit are drawn, and these gas is supplied to the fuel cell.

[0003] It is known that the internal resistance of the fuel cell at the time of a generation of electrical energy will influence the wettability of the electrolyte membrane inside a fuel cell, when sufficient humidity is not acquired but an electrolyte membrane dries, internal resistance becomes large and the power loss in a fuel cell increases. For this reason, in order to perform an efficient electric power supply, it is necessary to supply, where hydrogen and air are humidified and to maintain the humidity inside a fuel cell.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, in the present condition, control of the amount of humidification to the hydrogen and air which are supplied to a fuel cell is not performed. For this reason, lack or the case where it becomes superfluous has the moisture inside a fuel cell to the load which changes with time.

[0005] Drawing 12 shows the relation of the load to a fuel cell, a cel electrical potential difference, average current density, and the humidity of the air supplied, and when a load increases rapidly, if the moisture contents inside a fuel cell run short, the output of a fuel cell will decline. Thus, when moisture runs short, there is a problem that internal resistance increases and the output and generating efficiency of a fuel cell fall.

[0006] Moreover, there is a problem that the output of a fuel cell declines, without the water condensed in the interior of a fuel cell closing a gas passageway, and the gas for a generation of electrical energy spreading enough, or a generation of electrical energy is impossible by the water condensed at the time of low temperature being frozen, and starting becomes difficult when moisture is superfluous.

[0007] In view of the above-mentioned trouble, this invention keeps the moisture condition inside a fuel cell the optimal, and aims at offering the fuel cell system which enables an efficient generation of electrical energy.

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MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, in invention according to claim 1 It is a fuel cell system equipped with the fuel cell (10) which carries out electrochemical reaction of hydrogen and the oxygen, and generates electrical energy. A humidification means to humidify oxygen at least among the hydrogen supplied to a fuel cell (10), and oxygen (22 24), An electrical-potential-difference current detection means to detect the output voltage value and output current value of a fuel cell (10) (13), It is based on the internal resistance value (R_p) of the fuel cell (10) calculated from the demand electric energy (P_r) over a fuel cell (10), and the output voltage value and output current value detected with the electrical-potential-difference current detection means (13). It is characterized by having the control section (40) which controls whenever [humidification / of the oxygen supplied to a fuel cell (10)].

[0009] Thus, the wettability of the electrolyte membrane inside a fuel cell (10) can be maintained at an optimum state by controlling whenever [humidification / of oxygen] based on the demand electric energy (P_r) over a fuel cell (10), and the internal resistance value (R_p) of a fuel cell (10). In addition, "oxygen" includes the air not only containing an oxygen gas independent but oxygen gas in this specification.

[0010] Moreover, by invention according to claim 2, since it can presume that the moisture in a fuel cell is insufficient when the internal resistance value of a fuel cell (10) is large, when the ratio of an internal resistance value (R_p) to the internal resistance theoretical value (R_r) of the fuel cell (10) in demand electric energy (P_r) is over the predetermined value, the increment in a predetermined value of whenever [target humidification] is carried out.

[0011] Moreover, by invention according to claim 3, since the moisture in a fuel cell runs short when the load effect of a fuel cell is large (i.e., when fluctuation of the demand electric energy over a fuel cell is large), when the variation (ΔP_r) of demand electric energy (P_r) is over predetermined variation, the increment in a predetermined value of whenever [target humidification / of oxygen] is carried out.

[0012] Moreover, in invention according to claim 4, the control section (40) is characterized by setting up the initial value of whenever [target humidification] highly as compared with the case where current density is not over predetermined current density, when the current density of the fuel cell (10) needed since a fuel

cell (10) outputs demand electric energy (Pr) is over predetermined current density.

[0013] Thus, whenever [air target humidification] can be made into a quicker suitable value by setting up the initial value of whenever [air target humidification] low at the time of low loading, and setting it up highly at the time of a heavy load. In addition, it may replace with the current density of a fuel cell (10), and the initial value of whenever [target humidification] may be set up based on the demand electric energy over a fuel cell.

[0014] Moreover, a humidification means can use the bubbling-type humidification equipment (22) which passes gas for the water stored in the tank like invention according to claim 5, or can use the injector-type humidification equipment (24) which injects water for the oxygen supplied to a fuel cell (10) like invention according to claim 6.

[0015] In addition, the sign in the parenthesis of each above-mentioned means shows correspondence relation with the concrete means of a publication to the operation gestalt mentioned later.

[0016]

[Embodiment of the Invention] (The 1st operation gestalt) The 1st operation gestalt of this invention is hereafter explained based on drawing 1 - drawing 8 . A **** 1 operation gestalt applies a fuel cell system to the electric vehicle (fuel cell car) which runs a fuel cell as a power source.

[0017] Drawing 1 shows the whole fuel cell system configuration of an operation gestalt. As shown in drawing 1 , the fuel cell system of this operation gestalt is equipped with the fuel cell (FC stack) 10 which generates power using the electrochemical reaction of hydrogen and oxygen. The solid-state polyelectrolyte mold fuel cell is used as a FC stack 10, two or more laminatings of the cel used as a base unit are carried out, and it consists of **** 1 operation gestalten. Each cel has the composition that the electrolyte membrane was inserted with the electrode of a pair.

[0018] In the FC stack 10, the electrochemical reaction of the following hydrogen and oxygen occurs and electrical energy occurs.

(Negative-electrode side) The $H_2 \rightarrow 2H^{++} + 2e^{-}$ (positive-electrode side)

$2H^{++} + 1/2O_2 + 2e^{-} \rightarrow H_2O$ FC stack 10 is constituted so that power may be supplied to electrical machinery and apparatus, such as an inverter 11 and a rechargeable battery which is not illustrated. An inverter 11 changes into alternating current the direct current supplied from the FC stack 10, supplies it to a drive motor (load) 12, and is driving the motor 12. Drawing 2 is the enlarged drawing of the electrical-potential-difference current detecting element of the FC stack 10 in a fuel cell system, and as shown in drawing 2 , the electrical-potential-difference current detecting element 13 which detects the output voltage value and output current value of the FC stack 10 is formed in the FC stack 10.

[0019] Drawing 3 is the enlarged drawing of the gas supply section in a fuel cell system. As shown in drawing 3 , the air path 20 for supplying air (oxygen) to the oxygen pole (positive electrode) side of the FC stack 10 and the hydrogen path 30 for supplying hydrogen to the hydrogen pole (negative electrode) side of the FC stack 10 are formed in the fuel cell system. Air supply equipment 21 is formed in

the air path 20, and the hydrogen feeder 31 is formed in the hydrogen path 30. As air supply equipment 21, the blower for air feeding (gas-compression machine) can be used, for example, and steam-reforming equipment can be used as a hydrogen feeder 31, for example.

[0020] It is necessary to make the electrolyte membrane in the FC stack 10 into the damp or wet condition containing moisture for the electrochemical reaction at the time of a generation of electrical energy. For this reason, the humidification equipment 22 for humidifying to air is formed in the air path 20. Similarly, the humidification equipment 32 for humidifying in hydrogen is formed in the hydrogen path 30. As shown in drawing 3, with the **** 1 operation gestalt, the humidification equipment of the bubbling method which the water in a tank is made to pass gas and is humidified in it is used for the humidification equipments 22 and 32.

[0021] Humidification is performed in the hydrogen which passes the air and the hydrogen path 30 of passing the air path 20, with these humidification equipments 22 and 32, and the air and hydrogen which were humidified are supplied to the FC stack 10. By this, the FC stack 10 interior will operate by the damp or wet condition.

[0022] In the fuel cell system of a **** 1 operation gestalt, as shown in drawing 3, the bypass paths 20a and 30a of the humidification equipments 22 and 32 are formed in the air path 20 and the hydrogen path 30, respectively. The passage selector valves 23 and 33 are formed in the branch point of each gas paths 20 and 30 and bypass paths 20a and 30a. the passage selector valves 23 and 33 -- it is constituted so that gas may be passed to humidification equipment 21 and 31 side and gas may be passed to the bypass path 20a and 30a side in a sink and bulb-off by bulb-on.

[0023] Here, the amount control of humidification to the air or hydrogen by the humidification equipments 22 and 32 is explained. The amount control of humidification of the gas supplied to the FC stack 10 carries out duty ratio control of the passage selector valves 23 and 33, and is performed because gas controls the time amount rate of passing through the humidification equipments 22 and 32 and the bypass paths 20a and 30a.

[0024] Drawing 4 is the control explanatory view of the humidification equipments 22 and 32. Drawing 4 (a) is the map which set up beforehand the relation between Hr (%RH: relative humidity) and the bulb-on duty Dt (%) whenever [target humidification], and drawing 4 (b) shows the relation between the valve-action period Tp (second) and the bulb-on time amount Ton (second). The bulb-on duty Dt is the rate of the bulb-on time amount Ton in the valve-action period Tp. The map of drawing 4 (a) is suitably set up according to the class of humidification equipments 22 and 32 etc. The valve-action period Tp can be set as arbitration, and is made into Tp= 5 seconds with this operation gestalt.

[0025] Based on whenever [target humidification], the bulb-on duty Dt is searched for from the map of drawing 4 (a), and the bulb-on time amount Ton over the valve-action period Tp is found by $Ton = Tp \times Dt / 100$ (second).

[0026] Drawing 5 shows the migration condition of the moisture in the FC stack 10 interior. As shown in drawing 5, in the FC stack 10 interior, the moisture by the

side of air pole 10c diffuses the inside of electrolyte membrane 10b in the hydrogen pole 10a side from the air pole 10c side. The conductivity of electrolyte membrane 10b will be kept to some extent large by this moisture diffusion.

[0027] Drawing 6 shows the relation of hydrogen humidity (%RH) in case air humidity is 100%RH, current density (A/cm²), and single cell voltage (V). Drawing 6 shows that the relation between current density and a cell electrical potential difference hardly receives effect in change of hydrogen humidity.

[0028] Therefore, by the fuel cell system of a **** 1 operation gestalt, the amount of humidification of hydrogen is reduced as much as possible, and humidity control of the FC stack 10 interior is performed by mainly controlling the amount of humidification of air.

[0029] The control section (ECU) 40 which performs various control is formed in the fuel cell system of this operation gestalt. The control section 40 is equipped with the desired value operation part 41 which calculates whenever [target humidification / of gas], and the amount control section 42 of humidification which controls the amount of gas humidification based on whenever [target humidification]. An electrical-potential-difference value, a current value, etc. from a demand power signal and the electrical-potential-difference current detecting element 13 from a load 11 are inputted into a control section 40. Moreover, the control section 50 is constituted so that a control signal may be outputted to an inverter 11, gas transfer units 21 and 31, the passage selector valve 23, and 33 grades.

[0030] Next, actuation of the fuel cell system of the above-mentioned configuration is explained based on drawing 7. Drawing 7 is a flow chart which shows actuation of the fuel cell system of this operation gestalt. In addition, let control periods be several mm second – dozens mses.

[0031] First, the target humidity Hh of hydrogen is set up (step S10), and the target humidity basic value Hbo of air is set up (step S11). The hydrogen target humidity Hh is set for example, as RH 20%, and the air target humidity basic value Hbo is set for example, as RH 30%. The initial value of the air target humidity correction value Hfbo is set as 0 (step S12).

[0032] Next, based on signals, such as accelerator opening, the vehicle speed, and a brake, the demand power Pr needed for car transit is detected (step S13). Difference deltaPr with the demand power Pr at the time of control (t-1) is computed the current demand power Pr (t) and last time (step S14), and it judges whether variation deltaPr of demand power is over the predetermined value alpha (for example, 5kW) (step S15). That is, it judges whether the load effect to the FC stack 10 is rapid increase.

[0033] Consequently, when variation deltaPr of demand power is over the predetermined value alpha, first, the electrical-potential-difference current detecting element 13 detects the current output voltage value **** and the current output current value Ip of the FC stack 10 (step S16), and the current internal resistance value Rp of the FC stack 10 is computed by $Rp=****/Ip$ (step S17).

[0034] Next, the internal resistance reference value Rr of the FC stack 10 in the demand power Pr detected at the above-mentioned step S13 is calculated (step

S18). Drawing 8 is the map which set up beforehand the relation between the demand power P_r and the internal resistance value R_r of the FC stack 10. From the map shown in drawing 8, the internal resistance reference value R_r when the FC stack 10 outputs the demand power P_r is calculated.

[0035] Next, it judges whether the ratio to the internal resistance reference value R_r in the demand power P_r of the current internal resistance value R_p is over the predetermined value β (for example, 110%), and whether it is $R_p/R_r \geq \beta$ (step S19). That is, it judges whether the actual internal resistance value R_p is too large to the internal resistance reference value R_r which is an internal resistance theoretical value to the demand electric energy P_r .

[0036] Consequently, since it is presumed that the actual internal resistance value R_p runs short of the moisture contents in the FC stack 10 beyond the predetermined value to the internal resistance reference value R_r in being large, only the predetermined value γ (for example, 1%RH) makes the air target humidity correction value H_{fbo} increase (step S20).

[0037] On the other hand, since it is presumed to the internal resistance reference value R_r that the moisture contents in the FC stack 10 are insufficient when the current internal resistance value R_p is smaller than a predetermined value, only the predetermined value γ decreases the air target humidity correction value H_{fbo} (step S21). Moreover, also when variation ΔP_r of demand power is not over the predetermined value α at the above-mentioned step S15, only the predetermined value γ decreases the air target humidity correction value H_{fbo} similarly. It can prevent that the amount of air humidification to which it is made to increase at step S20 increases to infinity by this.

[0038] Next, it asks for the final air target humidity H_o from the sum of the air target humidity basic value H_{bo} and the air target humidity correction value H_{fbo} (step S22). A bound value is set as this air target humidity H_o (step S23). That is, when the air target humidity H_o is smaller than 0%RH, it is set as RH 0%, and in being larger than 100%RH, it sets it as RH 100%.

[0039] Next, based on the air target humidity H_o and the hydrogen target humidity H_h , the humidification equipments 22 and 32 perform humidification control of air or hydrogen (step S24). As mentioned above, humidification control is performed by the duty ratio control using the passage selector valves 23 and 33 so that whenever [humidification / of the air and hydrogen which are supplied to the FC stack 10] may turn into the air target humidity H_o and the hydrogen target humidity H_h . Hereafter, it carries out by repeating the control loop of the above-mentioned steps S13-S24.

[0040] As mentioned above, an internal resistance value is presumed according to the condition of a load, and it becomes possible by controlling the amount of humidification of gas based on this internal resistance value to always make the optimal the moisture condition of the FC stack 10 interior. Thereby, an efficient generation of electrical energy is attained. Moreover, since the moisture content inside a fuel cell can be lessened, the starting nature of the fuel cell at the time of low temperature can also be raised.

[0041] In addition, the hydrogen target humidity H_h , the air target humidity basic value H_{bo} , and the predetermined values α , β , and γ are values which

can be set as arbitration according to the class of fuel cell etc.

[0042] (The 2nd operation gestalt) Next, the 2nd operation gestalt of this invention is explained based on drawing 9 . It differs in that the humidification equipment 32 with which the **** 2 operation gestalt was prepared in the hydrogen path 30 as compared with the above-mentioned 1st operation gestalt was omitted. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.

[0043] Drawing 9 shows the whole fuel cell system configuration of a **** 2 operation gestalt. As the above-mentioned 1st operation gestalt explained based on drawing 5 and drawing 6 , the output of a fuel cell hardly receives effect in the humidity of supply hydrogen. For this reason, as shown in drawing 9 , in the fuel cell system of a **** 2 operation gestalt, humidification equipment is not formed in the hydrogen path 30, but humidification equipment 22 is formed only in the air path 20, and humidity control of the FC stack 10 interior is performed by controlling the amount of humidification of a supply air.

[0044] In the FC stack 10 interior, since the moisture by the side of an air pole diffuses the inside of an electrolyte membrane in a hydrogen pole side, the conductivity of an electrolyte membrane is kept to some extent large by such configuration. Therefore, the same effectiveness as the fuel cell system of the above-mentioned 1st operation gestalt can be acquired also by the configuration of a **** 2 operation gestalt. Moreover, according to the configuration of a **** 2 operation gestalt, simplification of a system can be attained.

[0045] (The 3rd operation gestalt) Next, the 3rd operation gestalt of this invention is explained based on drawing 10 . As compared with the above-mentioned 1st operation gestalt, as for a **** 3 operation gestalt, the setting approaches of the air target humidity basic value H_{bo} differ. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.

[0046] Drawing 10 is a flow chart which shows the configuration procedure of the air target humidity basic value H_{bo} , and supports step S11 of drawing 7 explained with the above-mentioned 1st operation gestalt. Hereafter, based on drawing 10 , the setting approach of the air target humidity basic value H_{bo} in a **** 3 operation gestalt is explained.

[0047] First, based on signals, such as accelerator opening, accelerator opening, the vehicle speed, and a brake, the demand electric energy P_r needed for car transit is detected (step S110). Next, the current density I_r required since the FC stack 10 outputs the demand electric energy P_r is computed (step S111). The need [of receiving the demand electric energy P_r] current density I_r becomes settled uniquely according to the class of inverter 11.

[0048] Next, it judges whether the load to whether the need current density I_r is over predetermined current density and the FC stack 10 is a heavy load, or it is low loading (step S112). The predetermined current density which is the reference value of whether it is a heavy load or to be low loading is the value which can be set as arbitration according to the class of fuel cell etc., for example, as shown in drawing 12 , it can be set up with 0.3 A/cm².

[0049] Consequently, when the need current density I_r is over the predetermined value, the air target humidity basic value H_{bo} is set for example, as RH 80 to 100%

(step S113). On the other hand, when the need current density I_r is not over the predetermined value, the air target humidity basic value H_{bo} is set for example, as RH 20 to 30% (step S114). It is the value which can also set these values as arbitration according to the class of fuel cell etc.

[0050] Thus, H_o can be made into a quicker suitable value whenever [air target humidification] by setting up the initial value of the air target humidity H_o low at the time of low loading, and setting it up highly at the time of a heavy load.

[0051] (The 4th operation gestalt) Next, the 4th operation gestalt of this invention is explained based on drawing 11 . As for a **** 4 operation gestalt, the configurations of the humidification equipments 22 and 32 differ as compared with the above-mentioned 1st operation gestalt. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.

[0052] Drawing 11 is the schematic diagram of the fuel cell system of a **** 4 operation gestalt. The same part as the above-mentioned 1st operation gestalt is omitting illustration suitably.

[0053] As shown in drawing 11 , with the **** 4 operation gestalt, the injector-type gas humidification equipments 24 and 34 are formed. Pure water is supplied from the pure tank 14, and the injector type humidification equipments 24 and 34 inject water in a gas passageway 20 and 30 based on the control signal from a control section 40, and they are constituted so that it may humidify in gas. Based on the air target humidity H_o and the hydrogen target humidity H_h , the moisture injection quantity is controlled by the injector type humidification equipments 24 and 34.

[0054] Responsibility becomes possible [performing highly precise humidification control] well more by using such injector type humidification equipments 24 and 34.

[0055] (Other operation gestalten) although controlled in addition by establishing the bypass paths 20a and 30a in the bubbling type humidification equipments 22 and 32, and carrying out duty ratio control whenever [humidification] with the above 1st - the 3rd operation gestalt -- not only this -- for example, humidity control can be performed also by adjusting the temperature of the humidified gas. By raising gas temperature, humidity can be made low and, specifically, humidity can be made high by lowering gas temperature.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the conceptual diagram of the fuel cell system of the above-mentioned 1st operation gestalt.

[Drawing 2] It is the expansion conceptual diagram of the fuel cell of drawing 1 .

[Drawing 3] It is the expansion conceptual diagram of the humidification equipment of drawing 1 .

[Drawing 4] It is the property Fig. showing humidification control of a humidifier.

[Drawing 5] It is the conceptual diagram showing the migration condition of the moisture in the interior of a fuel cell.

[Drawing 6] It is the property Fig. showing the relation of hydrogen humidity, air humidity, a cel electrical potential difference, and current density.

[Drawing 7] It is the flow chart which shows humidification control of the fuel cell system of the above-mentioned 1st operation gestalt.

[Drawing 8] It is the property Fig. showing the relation between demand power and internal resistance.

[Drawing 9] It is the conceptual diagram of the fuel cell system of the above-mentioned 2nd operation gestalt.

[Drawing 10] It is the flow chart of the fuel cell system of the above-mentioned 3rd operation gestalt.

[Drawing 11] It is the conceptual diagram of the fuel cell system of the above-mentioned 4th operation gestalt.

[Drawing 12] It is the property Fig. showing the relation of the load to a fuel cell, a cel electrical potential difference, average current density, and the humidity of the air supplied.

[Description of Notations]

10 [-- 22 A gas transfer unit, 32 / -- Humidification equipment, 40 / -- Control section.] -- A fuel cell (FC stack), 13 -- 20 An electrical-potential-difference current detecting element, 30 -- 21 A gas path, 31

[Translation done.]

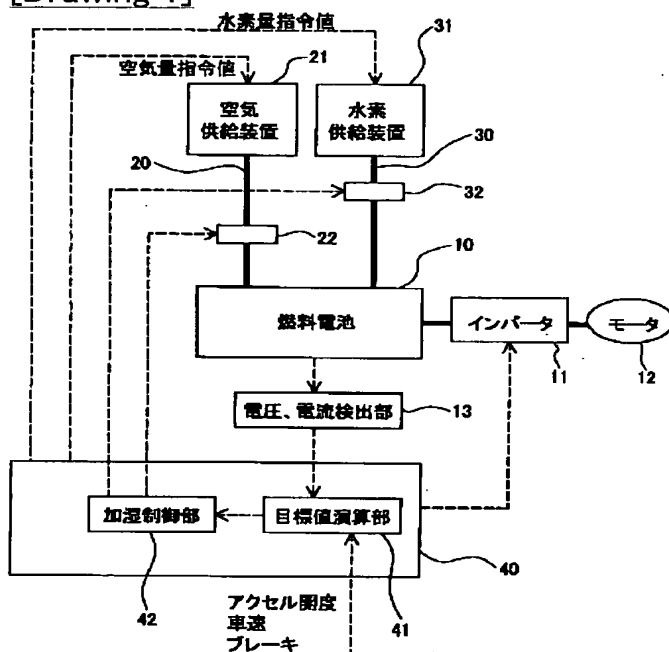
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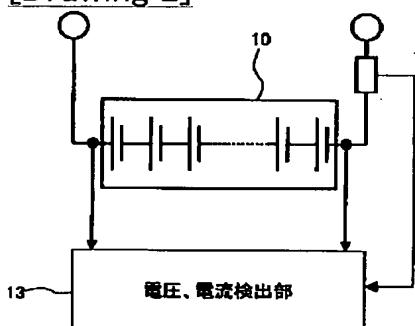
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DRAWINGS

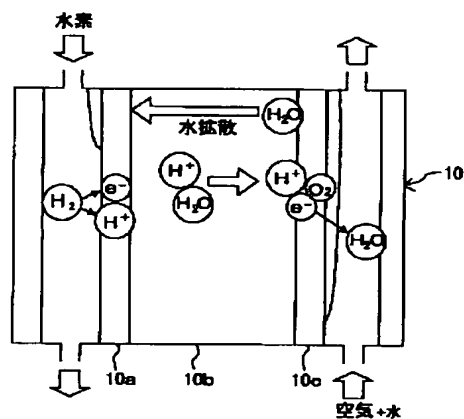
[Drawing 1]



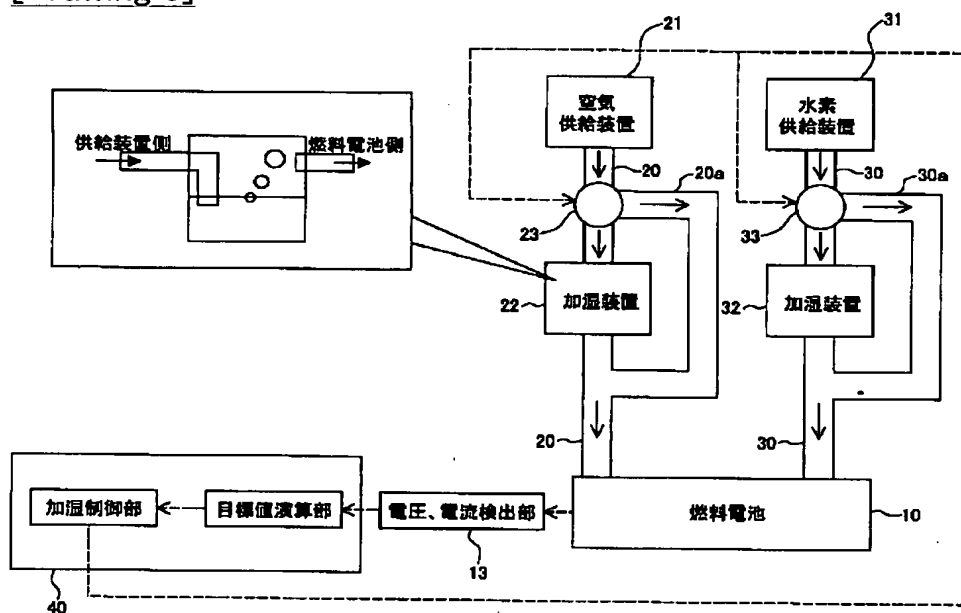
[Drawing 2]



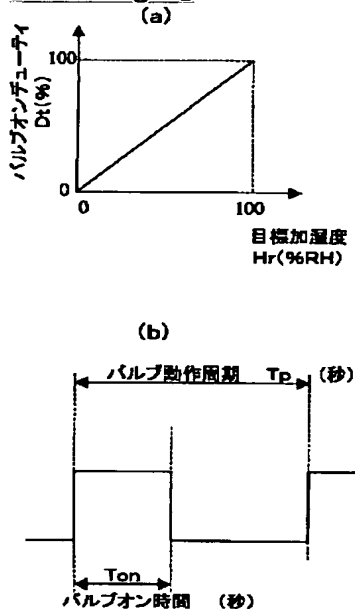
[Drawing 5]



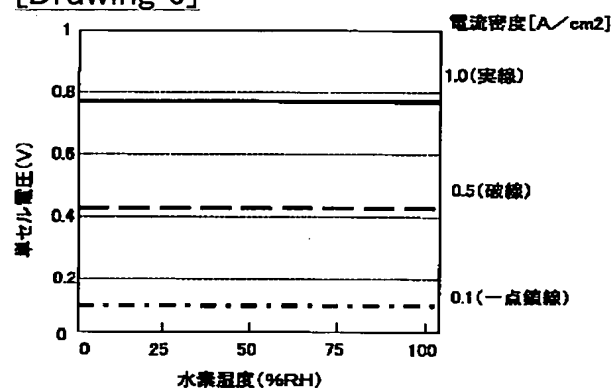
[Drawing 3]



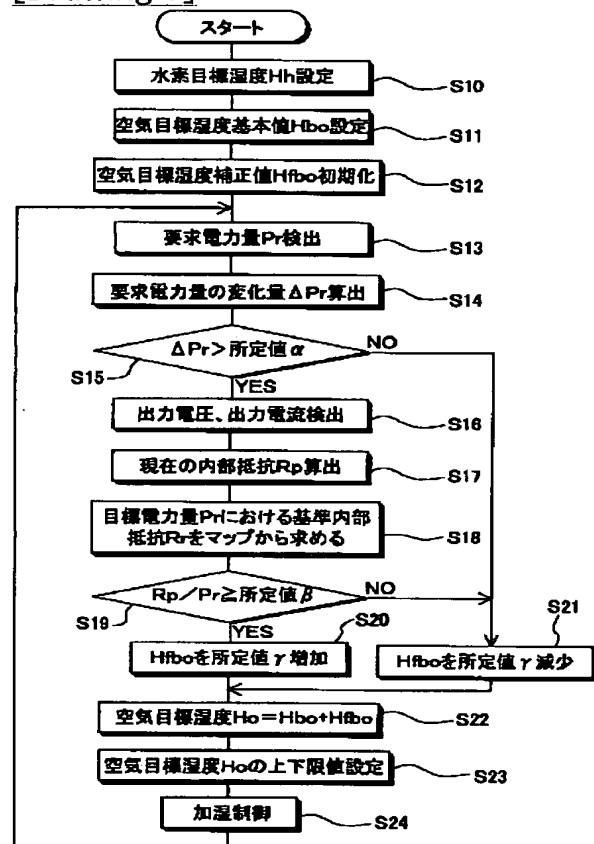
[Drawing 4]



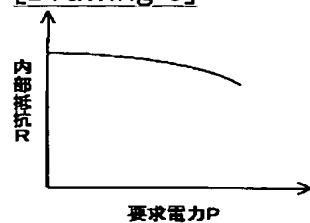
[Drawing 6]



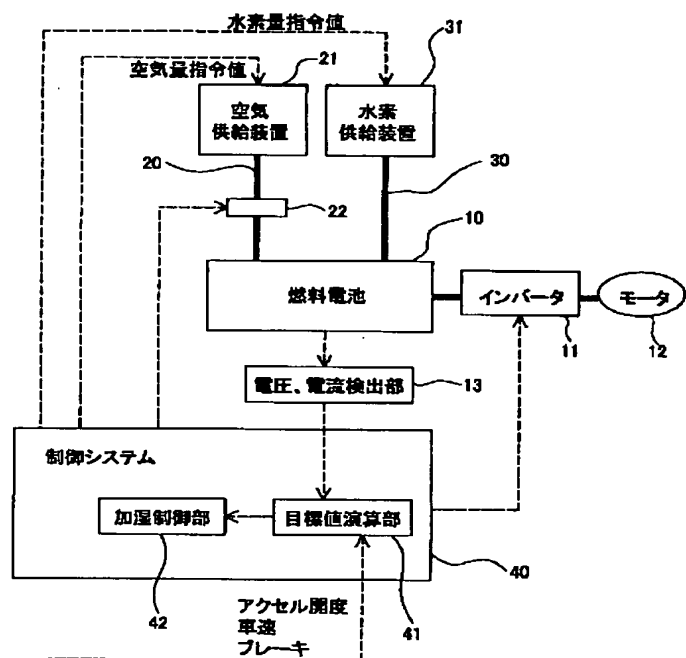
[Drawing 7]



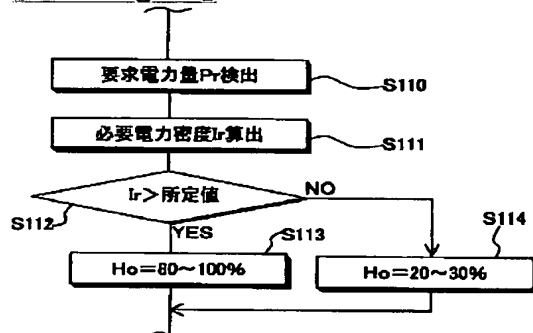
[Drawing 8]



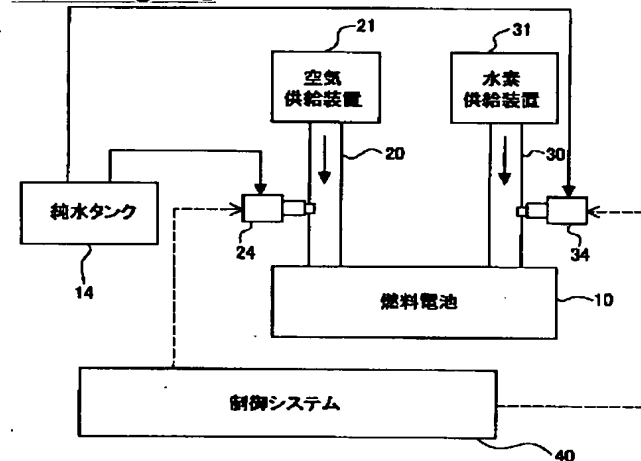
[Drawing 9]



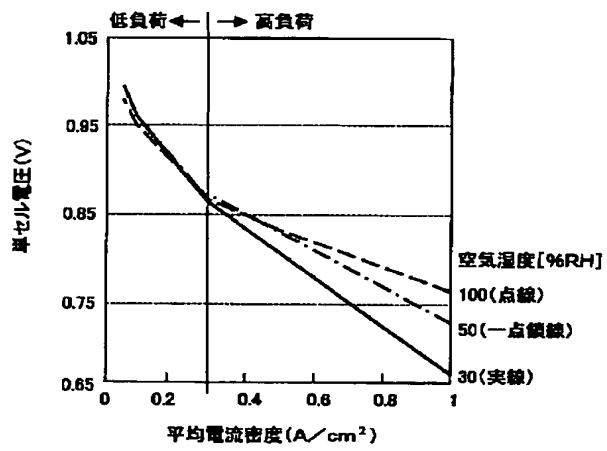
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号
特開2002-252011
(P2002-252011A)

(43) 公開日 平成14年9月6日 (2002.9.6)

(51) Int.Cl. ⁷	識別記号	F I	テマコード [*] (参考)
H 0 1 M 8/04		H 0 1 M 8/04	K 5 H 0 2 6
8/10		8/10	5 H 0 2 7

審査請求 未請求 請求項の数 6 O L (全 8 頁)

(21) 出願番号 特願2001-48712(P2001-48712)

(22) 出願日 平成13年2月23日 (2001.2.23)

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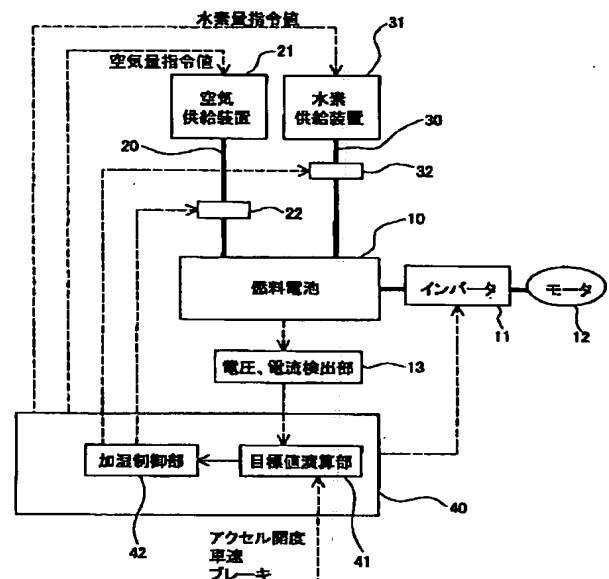
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(54) 【発明の名称】 燃料電池システム

(57) 【要約】

【課題】 燃料電池内部の水分状態を最適に保ち、高効率な発電を可能とする燃料電池システムを提供する。

【解決手段】 燃料電池10に対する要求電力量 P_r と、電圧電流検出手段13にて検出した出力電圧値および出力電流値から求められる燃料電池10の内部抵抗値 R_p とに基づいて、燃料電池10に供給される酸素の加湿度を制御する。要求電力量 P_r における燃料電池10の内部抵抗理論値 R_r に対する内部抵抗値 R_p の比が所定値を超えている場合には、水分が不足していると推定できるので、燃料電池10に供給される酸素の加湿度を所定量増加させる。



【特許請求の範囲】

【請求項1】 水素と酸素とを電気化学反応させて電気エネルギーを発生させる燃料電池(10)を備える燃料電池システムであって、

前記燃料電池(10)に供給される水素および酸素のうち少なくとも酸素を加湿する加湿手段(22、24)と、

前記燃料電池(10)の出力電圧値および出力電流値を検出する電圧電流検出手段(13)と、

前記燃料電池(10)に対する要求電力量(P_r)と、前記電圧電流検出手段(13)にて検出した前記出力電圧値および前記出力電流値から求められる前記燃料電池(10)の内部抵抗値(R_p)とに基づいて、前記燃料電池(10)に供給される酸素の加湿度を制御する制御部(40)とを備えることを特徴とする燃料電池システム。

【請求項2】 前記制御部(40)は、前記燃料電池(10)に供給される酸素の加湿度が目標加湿度になるように加湿度制御を行うものであり、前記要求電力量(P_r)における前記燃料電池(10)の内部抵抗理論値(R_r)に対する前記内部抵抗値(R_p)の比が所定値を超えている場合に、前記目標加湿度を所定値増加させることを特徴とする請求項1に記載の燃料電池システム。

【請求項3】 前記制御部(40)は、前記要求電力量(P_r)の変化量(ΔP_r)が所定変化量を超えている場合に、前記目標加湿度を所定値増加させることを特徴とする請求項2に記載の燃料電池システム。

【請求項4】 前記制御部(40)は、前記燃料電池(10)が前記要求電力量(P_r)を出力するために必要とされる前記燃料電池(10)の電流密度が所定電流密度を超えている場合には、前記電流密度が所定電流密度を超えていない場合に比較して、前記目標加湿度の初期値を高く設定することを特徴とする請求項1ないし3のいずれか1つに記載の燃料電池システム。

【請求項5】 前記加湿手段はタンク内に貯蔵された水にガスを通過させるバブリング式の加湿装置(22)であって、前記加湿装置(22)は前記燃料電池(10)に供給される酸素が前記加湿装置をバイパスできるバイパス経路(20a)を備えており、前記制御部(40)は、前記酸素が前記加湿装置(22)を通過する時間と前記バイパス経路(20a)を通過する時間との割合を制御して、前記酸素の加湿度を制御することを特徴とする請求項1ないし4のいずれか1つに記載の燃料電池システム。

【請求項6】 前記加湿手段は、前記燃料電池(10)に供給される酸素に水を噴射するインジェクタ式の加湿装置(24)であって、前記制御部(40)は、前記加湿装置(24)の水分噴射量を制御して、前記酸素の加湿度を制御することを特

徴とする請求項1ないし4のいずれか1つに記載の燃料電池システム。

【発明の詳細な説明】**【0001】**

【発明の属する技術分野】 本発明は、水素と酸素との化学反応により電気エネルギーを発生させる燃料電池からなる燃料電池システムに関するもので、車両、船舶及びポータブル発電器等の移動体に適用して有効である。

【0002】

【従来の技術】 例えば電気自動車に搭載される燃料電池システムでは、燃料電池が車両走行に必要な電力を発電するための水素量および酸素量(空気量)を導出し、これらのガスを燃料電池に供給している。

【0003】 発電時における燃料電池の内部抵抗は、燃料電池内部の電解質膜の湿潤度に影響することが知られており、十分な湿潤が得られず電解質膜が乾燥した場合には、内部抵抗が大きくなり燃料電池内における電力損失が増大する。このため、効率のよい電力供給を行うためには、水素および空気を加湿した状態で供給し、燃料電池内部の湿潤を保つ必要がある。

【0004】

【発明が解決しようとする課題】 ところが、現状では燃料電池に供給される水素および空気に対する加湿度の制御は行われていない。このため、経時的に変化する負荷に対して、燃料電池内部の水分が不足あるいは過剰となる場合がある。

【0005】 図12は燃料電池に対する負荷、セル電圧、平均電流密度、供給される空気の湿度の関係を示しており、負荷が急激に増大した場合に、燃料電池内部の水分量が不足していると燃料電池の出力が低下する。このように、水分が不足した場合には、内部抵抗が増大して燃料電池の出力および発電効率が低下するという問題がある。

【0006】 また、水分が過剰である場合には、燃料電池内部において凝縮した水がガス流路を塞いでしまい、発電のためのガスが充分行き渡らずに燃料電池の出力が低下したり、低温時において凝縮した水が凍結することで発電ができず起動が困難になるという問題がある。

【0007】 本発明は、上記問題点を鑑み、燃料電池内部の水分状態を最適に保ち、高効率な発電を可能とする燃料電池システムを提供することを目的とする。

【0008】

【課題を解決するための手段】 上記目的を達成するため、請求項1に記載の発明では、水素と酸素とを電気化学反応させて電気エネルギーを発生させる燃料電池(10)を備える燃料電池システムであって、燃料電池(10)に供給される水素および酸素のうち少なくとも酸素を加湿する加湿手段(22、24)と、燃料電池(10)の出力電圧値および出力電流値を検出する電圧電流検出手段(13)と、燃料電池(10)に対する要求電

力量（ P_r ）と、電圧電流検出手段（13）にて検出した出力電圧値および出力電流値から求められる燃料電池（10）の内部抵抗値（ R_p ）とに基づいて、燃料電池（10）に供給される酸素の加湿度を制御する制御部（40）とを備えることを特徴としている。

【0009】このように、燃料電池（10）に対する要求電力量（ P_r ）と、燃料電池（10）の内部抵抗値（ R_p ）に基づいて酸素の加湿度を制御することにより、燃料電池（10）内部の電解質膜の湿潤度を最適状態に保つことができる。なお、本明細書中においては、「酸素」は酸素ガス単独のみならず、酸素ガスを含んでいる空気を含む。

【0010】また、燃料電池（10）の内部抵抗値が大きい場合には、燃料電池内の水分が不足していると推定できるため、請求項2に記載の発明では、要求電力量（ P_r ）における燃料電池（10）の内部抵抗理論値（ R_r ）に対する内部抵抗値（ R_p ）の比が所定値を超えている場合に、目標加湿度を所定値増加させている。

【0011】また、燃料電池の負荷変動が大きい場合、すなわち、燃料電池に対する要求電力量の変動が大きい場合に燃料電池内の水分が不足することから、請求項3に記載の発明では、要求電力量（ P_r ）の変化量（ ΔP_r ）が所定変化量を超えている場合に、酸素の目標加湿度を所定値増加させている。

【0012】また、請求項4に記載の発明では、制御部（40）は、燃料電池（10）が要求電力量（ P_r ）を出力するために必要とされる燃料電池（10）の電流密度が所定電流密度を超えている場合には、電流密度が所定電流密度を超えていない場合に比較して、目標加湿度の初期値を高く設定することを特徴としている。

【0013】このように、空気目標加湿度の初期値を、低負荷時には低く設定し、高負荷時には高く設定することで、空気目標加湿度をより速く適切な値にすることができる。なお、燃料電池（10）の電流密度に代えて、燃料電池に対する要求電力量に基づいて目標加湿度の初期値を設定してもよい。

【0014】また、加湿手段は、請求項5に記載の発明のように、タンク内に貯蔵された水にガスを通過させるバブリング式の加湿装置（22）を用いることができ、あるいは、請求項6に記載の発明のように、燃料電池（10）に供給される酸素に水を噴射するインジェクタ式の加湿装置（24）を用いることができる。

【0015】なお、上記各手段の括弧内の符号は、後述する実施形態に記載の具体的手段との対応関係を示すものである。

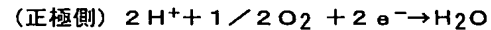
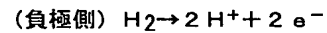
【0016】

【発明の実施の形態】（第1実施形態）以下、本発明の第1実施形態を図1～図8に基づいて説明する。本第1実施形態は、燃料電池システムを燃料電池を電源として走行する電気自動車（燃料電池車両）に適用したもので

ある。

【0017】図1は、実施形態の燃料電池システムの全体構成を示している。図1に示すように、本実施形態の燃料電池システムは、水素と酸素との電気化学反応を利用して電力を発生する燃料電池（FCスタック）10を備えている。本第1実施形態ではFCスタック10として固体高分子電解質型燃料電池を用いており、基本単位となるセルが複数積層されて構成されている。各セルは、電解質膜が一对の電極で挟まれた構成となっている。

【0018】FCスタック10では、以下の水素と酸素の電気化学反応が起こり電気エネルギーが発生する。



FCスタック10は、インバータ11や図示しない2次電池等の電気機器に電力を供給するように構成されている。インバータ11は、FCスタック10から供給された直流電流を交流電流に変換して走行用モータ（負荷）12に供給し、モータ12を駆動している。図2は燃料電池システムにおけるFCスタック10の電圧電流検出部の拡大図であり、図2に示すようにFCスタック10には、FCスタック10の出力電圧値および出力電流値を検出する電圧電流検出部13が設けられている。

【0019】図3は、燃料電池システムにおけるガス供給部の拡大図である。図3に示すように、燃料電池システムには、FCスタック10の酸素極（正極）側に空気（酸素）を供給するための空気経路20と、FCスタック10の水素極（負極）側に水素を供給するための水素経路30が設けられている。空気経路20には空気供給装置21が設けられ、水素経路30には水素供給装置31が設けられている。空気供給装置21としては、例えば空気圧送用の送風機（ガス圧縮機）を用いることができ、水素供給装置31としては、例えば水蒸気改質装置を用いることができる。

【0020】発電時における電気化学反応のために、FCスタック10内の電解質膜を水分を含んだ湿潤状態にしておく必要がある。このため、空気経路20には空気に加湿を行うための加湿装置22が設けられている。同様に、水素経路30には水素に加湿を行うための加湿装置32が設けられている。図3に示すように、本第1実施形態では、加湿装置22、32には、タンク内の水にガスを通過させて加湿するバブリング方式の加湿装置を用いている。

【0021】これらの加湿装置22、32により、空気経路20を通過する空気および水素経路30を通過する水素に加湿が行われ、FCスタック10には加湿された空気および水素が供給される。これにより、FCスタック10内部は湿潤状態で作動することとなる。

【0022】本第1実施形態の燃料電池システムでは、図3に示すように、空気経路20および水素経路30に

は、それぞれ加湿装置22、32のバイパス経路20a、30aが設けられている。それぞれのガス経路20、30とバイパス経路20a、30aとの分岐点には、流路切替弁23、33が設けられている。流路切替弁23、33は、バルブオンでガスを加湿装置21、31側に流し、バルブオフでガスをバイパス通路20a、30a側に流すように構成されている。

【0023】ここで、加湿装置22、32による空気あるいは水素への加湿量制御について説明する。FCスタック10に供給されるガスの加湿量制御は、流路切替弁23、33をデューティ比制御し、ガスが加湿装置22、32とバイパス通路20a、30aとを通過する時間割合を制御することで行う。

【0024】図4は加湿装置22、32の制御説明図である。図4(a)は目標加湿度 H_r (%RH: 相対湿度)とバルブオンデューティ D_t (%)との関係を予め設定したマップであり、図4(b)はバルブ動作周期 T_p (秒)とバルブオン時間 T_{on} (秒)との関係を示している。バルブオンデューティ D_t は、バルブ動作周期 T_p におけるバルブオン時間 T_{on} の割合である。図4(a)のマップは加湿装置22、32の種類等に従って適宜設定されるものである。バルブ動作周期 T_p は任意に設定でき、本実施形態では $T_p=5$ 秒としている。

【0025】図4(a)のマップから目標加湿度に基づいてバルブオンデューティ D_t を求め、バルブ動作周期 T_p に対するバルブオン時間 T_{on} を $T_{on}=T_p \times D_t / 100$ (秒)で求める。

【0026】図5はFCスタック10内部における水分の移動状態を示している。図5に示すように、FCスタック10内部では、空気極10c側の水分が電解質膜10b中を空気極10c側から水素極10a側に拡散する。この水分拡散により、電解質膜10bの伝導率がある程度大きく保たれることとなる。

【0027】図6は、空気湿度が100%RHの場合における、水素湿度(%RH)、電流密度(A/cm^2)、単セル電圧(V)の関係を示している。図6より、電流密度とセル電圧の関係は、水素湿度の変化にほとんど影響を受けないことが分かる。

【0028】従って、本第1実施形態の燃料電池システムでは、水素の加湿量を極力低減し、主に空気の加湿量を制御することで、FCスタック10内部の湿度制御を行っている。

【0029】本実施形態の燃料電池システムには各種制御を行う制御部(ECU)40が設けられている。制御部40には、ガスの目標加湿度を演算する目標値演算部41と、目標加湿度に基づいてガス加湿量を制御する加湿量制御部42を備えている。制御部40には、負荷11からの要求電力信号、電圧電流検出部13からの電圧値および電流値等が入力される。また、制御部50は、インバータ11、ガス供給装置21、31、流路切替弁

23、33等に制御信号を出力するように構成されている。

【0030】次に、上記構成の燃料電池システムの作動を図7に基づいて説明する。図7は本実施形態の燃料電池システムの作動を示すフローチャートである。なお、制御周期は数ミリ秒～数十ミリ秒とする。

【0031】まず、水素の目標湿度 H_h を設定し(ステップS10)、空気の目標湿度基本値 H_{bo} を設定する(ステップS11)。水素目標湿度 H_h を例えば20%RHに設定し、空気目標湿度基本値 H_{bo} を例えば30%RHに設定する。空気目標湿度補正值 H_{fb} の初期値を0に設定する(ステップS12)。

【0032】次に、アクセル開度、車速、ブレーキ等の信号に基づいて、車両走行に必要とされる要求電力 P_r を検出する(ステップS13)。現在の要求電力 $P_r(t)$ と前回制御時の要求電力 $P_r(t-1)$ との差 ΔP_r を算出し(ステップS14)、要求電力の変化量 ΔP_r が所定値 α (例えば5kW)を超えているか否かを判定する(ステップS15)。すなわち、FCスタック10に対する負荷変動が急激な増大であるか否かを判定する。

【0033】この結果、要求電力の変化量 ΔP_r が所定値 α を超えている場合には、まず、電圧電流検出部13によりFCスタック10の現在の出力電圧値 V_p および出力電流値 I_p を検出し(ステップS16)、FCスタック10の現在の内部抵抗値 R_p を、 $R_p=V_p/I_p$ で算出する(ステップS17)。

【0034】次に、上記ステップS13で検出した要求電力 P_r におけるFCスタック10の内部抵抗基準値 R_r を求める(ステップS18)。図8は、要求電力 P_r とFCスタック10の内部抵抗値 R_r との関係を予め設定したマップである。図8に示すマップから、FCスタック10が要求電力 P_r を出力した場合の内部抵抗基準値 R_r を求める。

【0035】次に、現在の内部抵抗値 R_p の要求電力 P_r における内部抵抗基準値 R_r に対する比が所定値 β (例えば110%)を超えているか否か、 $R_p/R_r \geq \beta$ であるか否かを判定する(ステップS19)。すなわち、要求電力量 P_r に対する内部抵抗理論値である内部抵抗基準値 R_r に対して、実際の内部抵抗値 R_p が大きすぎないか否かを判定する。

【0036】この結果、内部抵抗基準値 R_r に対して実際の内部抵抗値 R_p が所定値以上大きい場合には、FCスタック10内の水分量が不足していると推定されるので、空気目標湿度補正值 H_{fb} を所定値 γ (例えば1%RH)だけ増加させる(ステップS20)。

【0037】一方、内部抵抗基準値 R_r に対して現在の内部抵抗値 R_p が所定値より小さい場合には、FCスタック10内の水分量は不足していないと推定されるので、空気目標湿度補正值 H_{fb} を所定値 γ だけ減少さ

せる(ステップS21)。また、上記ステップS15で要求電力の変化量 ΔP_r が所定値 α を超えていない場合にも、同様に空気目標湿度補正值 H_{fb0} を所定値 γ だけ減少させる。これにより、ステップS20で増加させる空気加湿量が無限に増大するのを防止することができる。

【0038】次に、最終的な空気目標湿度 H_0 を、空気目標湿度基本値 H_{b0} と空気目標湿度補正值 H_{fb0} との和から求める(ステップS22)。この空気目標湿度 H_0 に上下限值を設定する(ステップS23)。すなわち、空気目標湿度 H_0 が0%RHより小さい場合には0%RHに設定し、100%RHより大きい場合には100%RHに設定する。

【0039】次に、空気目標湿度 H_0 および水素目標湿度 H_h に基づいて、加湿装置22、32により空気あるいは水素の加湿制御を行う(ステップS24)。加湿制御は、上述したように、流路切替弁23、33を用いたデューティ比制御により、FCスタック10に供給される空気および水素の加湿度が、空気目標湿度 H_0 および水素目標湿度 H_h となるように行われる。以下、上記ステップS13~S24の制御ループを繰り返し行う。

【0040】以上のように、負荷の状態に応じて内部抵抗値を推定し、この内部抵抗値に基づいてガスの加湿量を制御することで、FCスタック10内部の水分状態を常に最適にすることが可能となる。これにより高効率な発電が可能となる。また、燃料電池内部の水分量を少なくできるので、低温時における燃料電池の起動性も向上させることができる。

【0041】なお、水素目標湿度 H_h 、空気目標湿度基本値 H_{b0} および所定値 α 、 β 、 γ は、燃料電池の種類等に応じて任意に設定できる値である。

【0042】(第2実施形態)次に、本発明の第2実施形態を図9に基づいて説明する。本第2実施形態は、上記第1実施形態と比較して、水素経路30に設けられていた加湿装置32を省略した点が異なるものである。上記第1実施形態と同様の部分は、同一の符号を付して説明を省略する。

【0043】図9は、本第2実施形態の燃料電池システムの全体構成を示している。上記第1実施形態で図5、図6に基づいて説明したように、燃料電池の出力は供給水素の湿度にほとんど影響を受けない。このため、図9に示すように本第2実施形態の燃料電池システムでは、水素経路30には加湿装置を設けず、空気経路20のみ加湿装置22を設け、供給空気の加湿量を制御することでFCスタック10内部の湿度制御を行っている。

【0044】このような構成によっても、FCスタック10内部では空気極側の水分が電解質膜中を水素極側に拡散するため、電解質膜の伝導率がある程度大きく保たれる。従って、本第2実施形態の構成によっても、上記第1実施形態の燃料電池システムと同様の効果を得ること

とができる。また、本第2実施形態の構成によれば、システムの簡略化を図ることができる。

【0045】(第3実施形態)次に、本発明の第3実施形態を図10に基づいて説明する。本第3実施形態は、上記第1実施形態と比較して、空気目標湿度基本値 H_{b0} の設定方法が異なるものである。上記第1実施形態と同様の部分は、同一の符号を付して説明を省略する。

【0046】図10は空気目標湿度基本値 H_{b0} の設定手順を示すフローチャートであり、上記第1実施形態で説明した図7のステップS11に対応している。以下、図10に基づいて、本第3実施形態における空気目標湿度基本値 H_{b0} の設定方法を説明する。

【0047】まず、アクセル開度、アクセル開度、車速、ブレーキ等の信号に基づいて、車両走行に必要な要求電力量 P_r を検出する(ステップS110)。次に、FCスタック10が要求電力量 P_r を出力するために必要な電流密度 I_r を算出する(ステップS111)。要求電力量 P_r に対する必要電流密度 I_r は、インバータ11の種類によって一義的に定まる。

【0048】次に、必要電流密度 I_r が所定電流密度を超えているか否か、すなわちFCスタック10に対する負荷が高負荷であるか低負荷であるかを判定する(ステップS112)。高負荷であるか低負荷であるかの基準値である所定電流密度は、燃料電池の種類等に応じて任意に設定できる値であり、例えば図12に示すように $0.3A/cm^2$ と設定することができる。

【0049】この結果、必要電流密度 I_r が所定値を超えている場合には、空気目標湿度基本値 H_{b0} を例えば80~100%RHに設定する(ステップS113)。一方、必要電流密度 I_r が所定値を超えていない場合には、空気目標湿度基本値 H_{b0} を例えば20~30%RHに設定する(ステップS114)。これらの値も、燃料電池の種類等に応じて任意に設定できる値である。

【0050】このように、空気目標湿度 H_0 の初期値を、低負荷時には低く設定し、高負荷時には高く設定することで、空気目標加湿度 H_0 をより速く適切な値にすることができる。

【0051】(第4実施形態)次に、本発明の第4実施形態を図11に基づいて説明する。本第4実施形態は、上記第1実施形態と比較して、加湿装置22、32の構成が異なるものである。上記第1実施形態と同様の部分は、同一の符号を付して説明を省略する。

【0052】図11は、本第4実施形態の燃料電池システムの概略図である。上記第1実施形態と同様の部分は適宜図示を省略している。

【0053】図11に示すように本第4実施形態では、インジェクタ式のガス加湿装置24、34が設けられている。インジェクタ式加湿装置24、34は、純粋タンク14から純水が供給され、制御部40からの制御信号に基づいてガス通路20、30内に水を噴射し、ガスに

加湿するように構成されている。インジェクタ式加湿装置24、34では、空気目標湿度 H_o および水素目標湿度 H_h に基づいて水分噴射量が制御される。

【0054】このようなインジェクタ式加湿装置24、34を用いることで、より応答性がよく、かつ高精度な加湿制御を行うことが可能となる。

【0055】（他の実施形態）なお、上記第1～第3実施形態では、バブリング式加湿装置22、32にバイパス通路20a、30aを設けてデューティ比制御することで加湿度制御を行ったが、これに限らず、例えば加湿されたガスの温度を調整することによっても湿度制御を行うことができる。具体的には、ガス温度を上げることによって湿度を低くすることができ、ガス温度を下げることによって湿度を高くすることができる。

【図面の簡単な説明】

【図1】上記第1実施形態の燃料電池システムの概念図である。

【図2】図1の燃料電池の拡大概念図である。

【図3】図1の加湿装置の拡大概念図である。

【図4】加湿器の加湿制御を示す特性図である。

【図5】燃料電池内部における水分の移動状態を示す概

念図である。

【図6】水素湿度、空気湿度、セル電圧、電流密度の関係を示す特性図である。

【図7】上記第1実施形態の燃料電池システムの加湿制御を示すフローチャートである。

【図8】要求電力と内部抵抗との関係を示す特性図である。

【図9】上記第2実施形態の燃料電池システムの概念図である。

【図10】上記第3実施形態の燃料電池システムのフローチャートである。

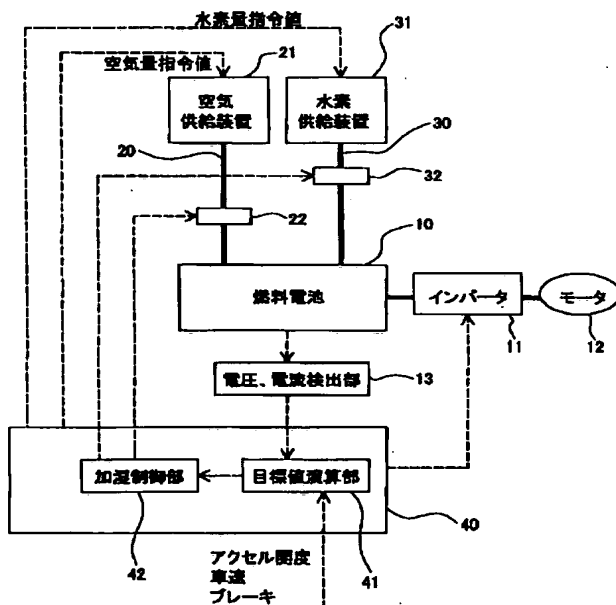
【図11】上記第4実施形態の燃料電池システムの概念図である。

【図12】燃料電池に対する負荷、セル電圧、平均電流密度、供給される空気の湿度の関係を示す特性図である。

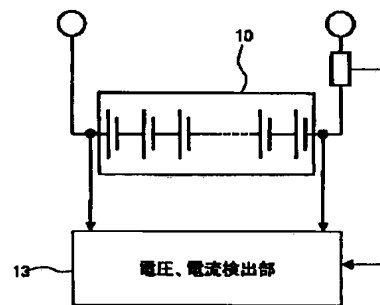
【符号の説明】

10…燃料電池（FCスタック）、13…電圧電流検出部、20、30…ガス経路、21、31…ガス供給装置、22、32…加湿装置、40…制御部。

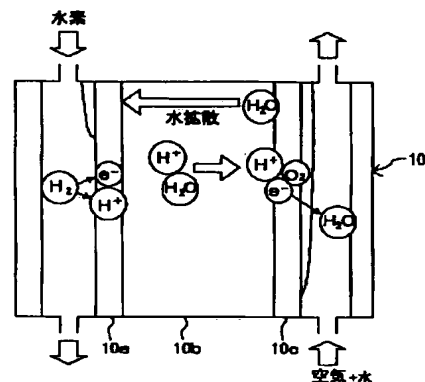
【図1】



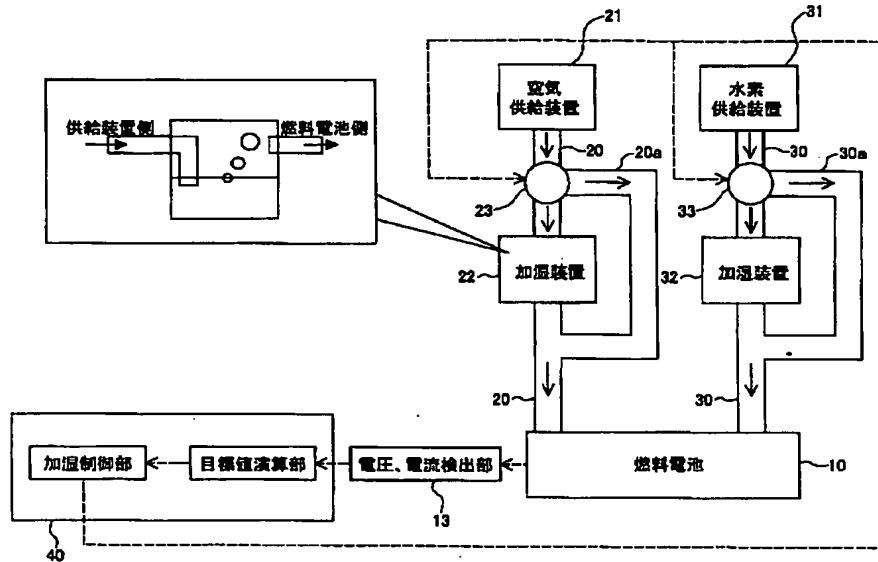
【図2】



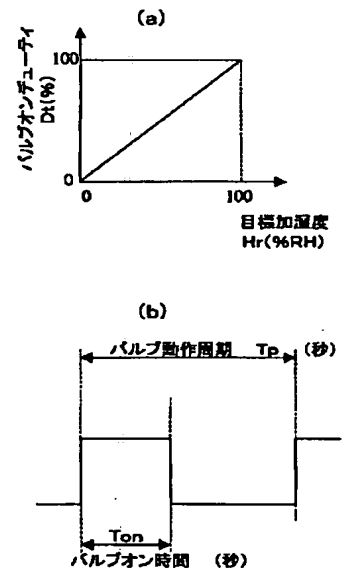
【図5】



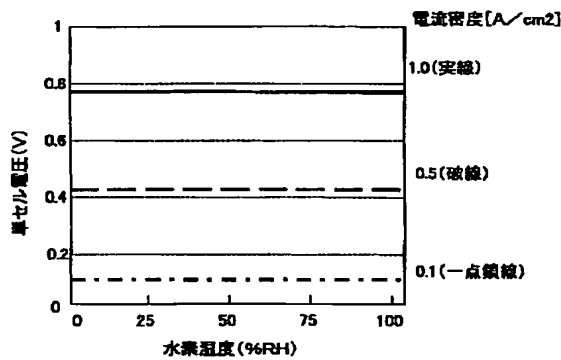
【図3】



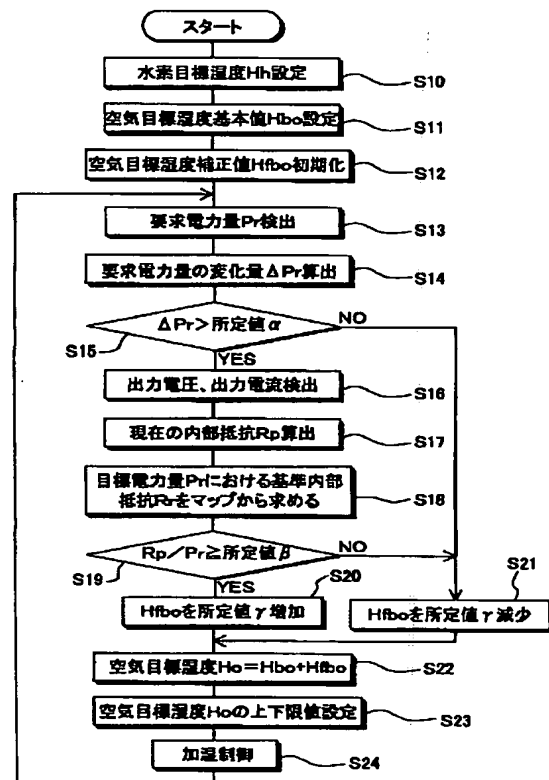
【図4】



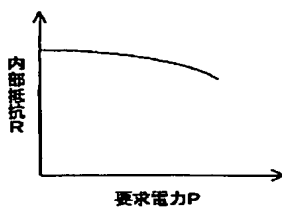
【図6】



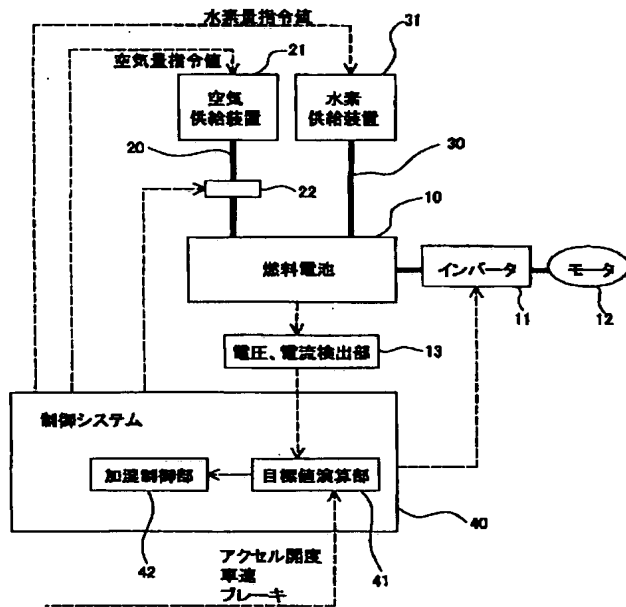
【図7】



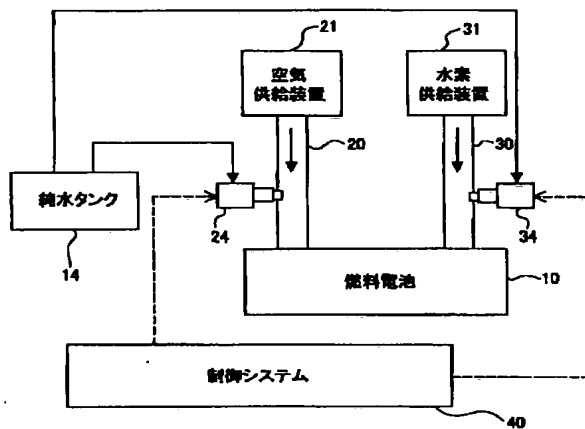
【図8】



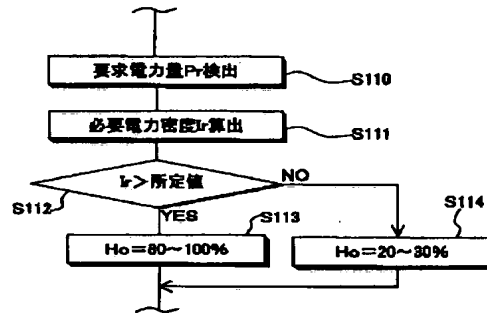
【図9】



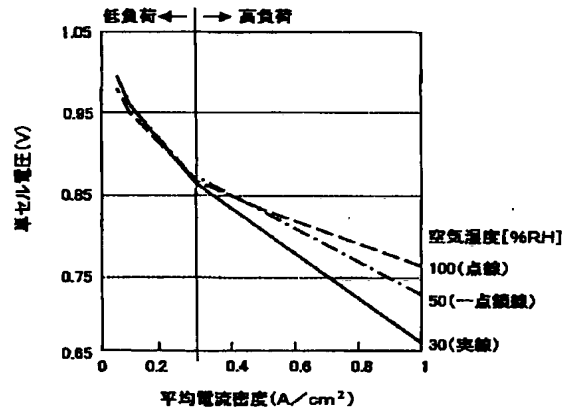
【図11】



【図10】



【図12】



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Fターム(参考) 5H026 AA06
5H027 AA06 BA01 DD03 KK54 KK56
MM01 MM04 MM09